Table 5-8. Comparison of measured and simulated annual peak discharge at USGS gaging station 10336580. Values are in cubic meters per second.

Water year	Observed	Water year	Observed
1991	8.72	1997	56.92
1992	4.59	1998	10.96
1993	13.20	1999	15.01
1994	5.75	2000	12.40
1995	15.55	2001	6.94
1996	26.76		

Table 5-9. Comparison of measured and simulated annual peak discharge at USGS gaging station 103366092. Values are in cubic meters per second.

Water year	Observed	CONCEPTS	Water year	Observed	CONCEPTS
1991	14.47	47.75	1997	144.98	182.47
1992	8.18	33.92	1998	24.15	43.78
1993	45.31	30.60	1999	34.83	27.81
1994	7.59	16.66	2000	23.50	28.06
1995	34.83	71.74	2001	9.97	22.31
1996	65.70	87.71			

Table 5-10. Comparison of measured and simulated annual peak discharge at USGS gaging station 10336610. Values are in cubic meters per second.

Water year	Observed	CONCEPTS	Water year	Observed	CONCEPTS
1981	9.97	51.15	1991	11.38	67.26
1982	72.21	125.41	1992	8.04	33.34
1983	36.81	55.01	1993	20.64	57.63
1984	39.08	69.80	1994	6.80	25.27
1985	13.00	42.44	1995	41.34	89.69
1986	77.59	150.53	1996	50.40	109.15
1987	15.09	28.23	1997	155.18	210.94
1988	4.81	23.14	1998	41.91	47.15
1989	16.85	51.50	1999	28.88	38.76
1990	6.68	36.17	2000	24.07	41.47

CONCEPTS Validation

Calculated suspended-sediment loads at stations 103366092 and 10336610 (see section 3.4) and the observed changes at cross sections 19 through 26 between 1992 and 2002 were used to validate CONCEPTS for the period from January 1981 through September 2001. Figures 5-61 through 5-64 show the results of the validation.

Changes in cross section geometry. In general, simulated changes in bed elevation along the Upper Truckee River are negligible, although there is 0.5 m of deposition at cross sections 24 and 44. Channel width adjustment is minor above river kilometer 18.There is approximately 1 m of widening between cross sections 12 and 15 and cross sections 38 and 44. Significant widening, up to 6 m, is simulated between cross sections 19 and 26. Figure 5-61 compares simulated cross-sectional changes at cross sections 19, 23, and 26 with those observed between 1992 and 2002. The simulated changes agree quite well with those observed. The simulated cross-sectional changes at cross sections 20, 21, 22, 24, and 25 (not plotted) compare fairly poorly with those observed. The channel segment containing these cross sections is highly sinuous. As a consequence, flow patterns are highly complex (three-dimensional) and cannot be captured by a one-dimensional flow model like CONCEPTS. For example, Figure 5-61C shows the flow-induced scour of the pool near the left bank of cross section 26.

Sediment Load. Figure 5-62 compares measured and simulated monthly loads of fines (clay- and silt-sized particles), sands, and total suspended sediments. The points plot around the line of perfect agreement. The observed scatter is to be expected in light of the variability between measured and simulated mean-monthly runoff (Figures 5-53 and 5-54). At station 103366092 the r^2 value for total suspended sediments is 0.40. At station 10336610 the r^2 values for the fines, sands, and total suspended sediments are respectively 0.45, 0.35, and 0.39.

Generally, annual loads appear to be correlated with annual runoff (Figure 5-63). Years with low runoff correspond to years with low annual sediment loads. The simulated annual load at gaging station 103366092 agrees quite well with that measured. However, the annual load in 1993 and 1995 is underpredicted. Figure 5-63A indicates that significant channel adjustments (bank widening) are simulated in 1997, because annual suspended-sediment load is relatively large. Between 1991 and 2001 the measured average annual total suspended-sediment load was 1287 T at station 103366092. The corresponding simulated average-annual load of total suspended sediment is 1251 T.

Between 1981 and 2001 the measured average annual fine, coarse, and total suspended sediment loads were 1258, 1700, and 2958 T/y, respectively at the downstream, index station 10336610. The corresponding simulated average annual loads are 1486, 2814, and 4300 T/y, respectively. The annual loads in 1986 and 1995 are underpredicted, whereas the annual loads for the low runoff years 1987 through 1992 are overpredicted (Figure 5-63B). It appears that too much sediment is transported at low discharges in the simulation. This discrepancy is mainly attributable to the high sand loads.

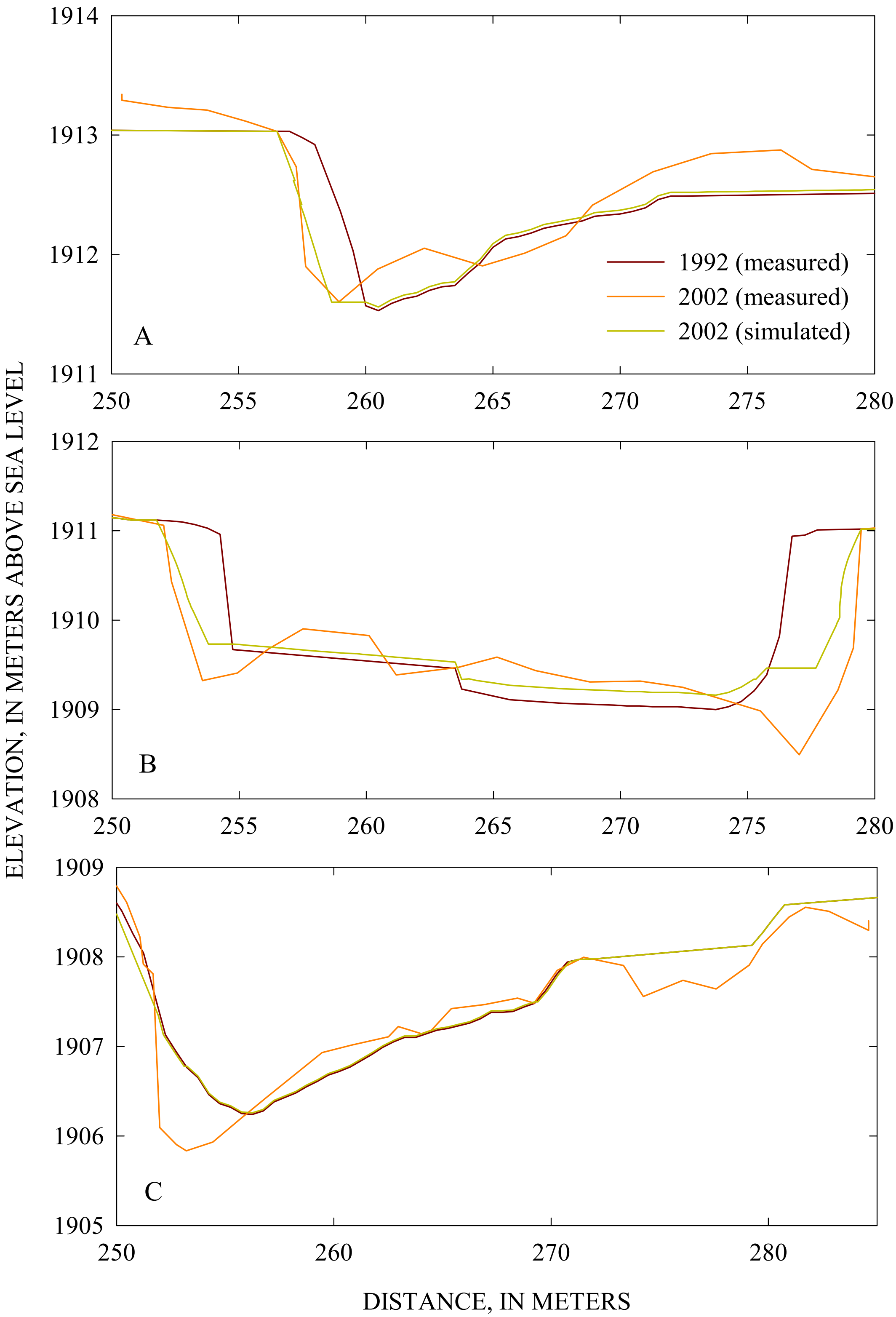

Figure 5-61. Comparison of observed and simulated cross-sectional changes at: A) CONCEPTS cross section 19 and 36, B) CONCEPTS cross section 23 and 50, and C) CONCEPTS cross section 26 and 61.

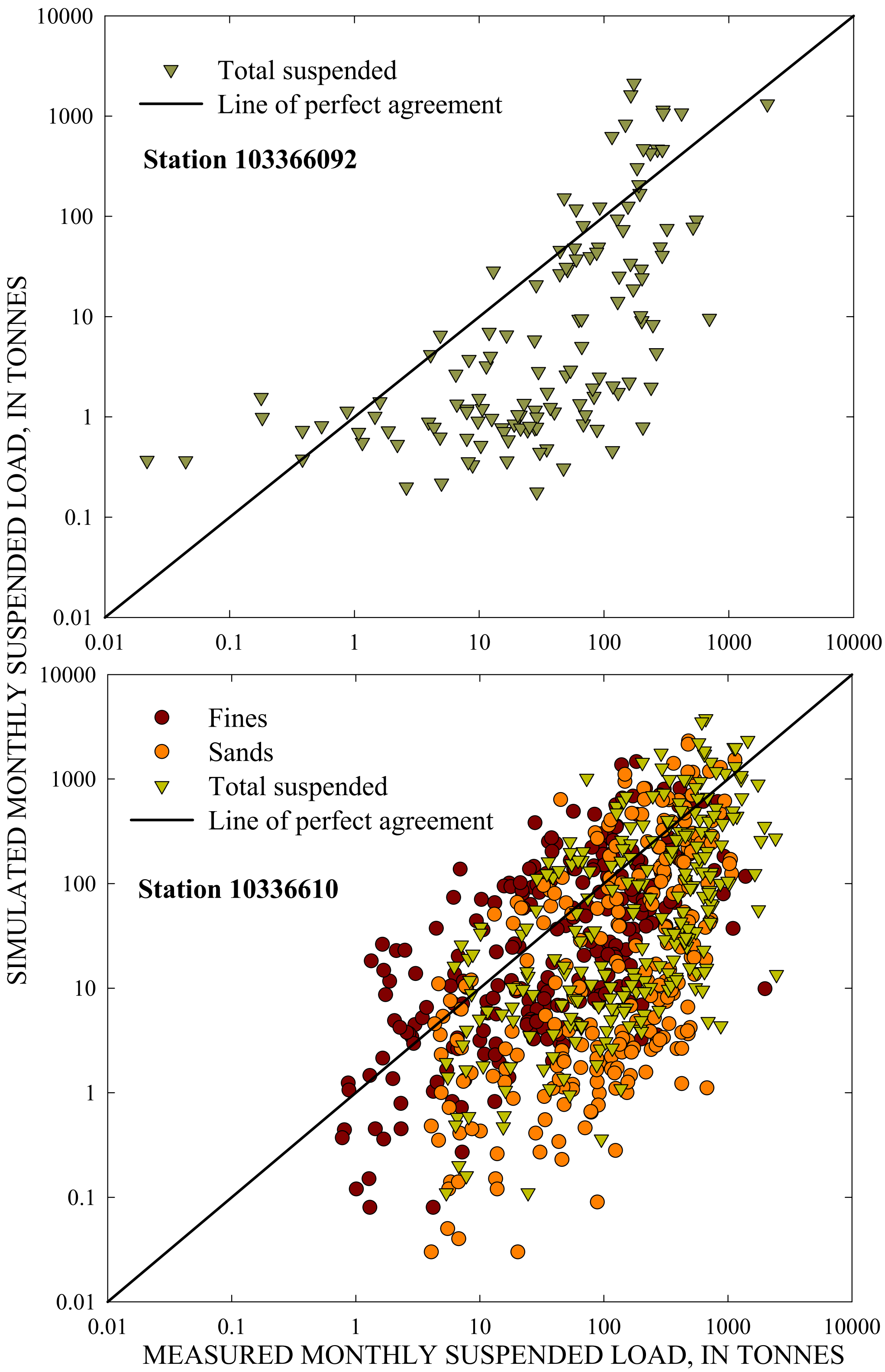

Figure 5-62. Comparison of measured and simulated mean-monthly total suspended sediments for USGS Gages 103366092 (A) and 10336610 (B), for the periods 1991-2001 and 1981-2001, respectively.

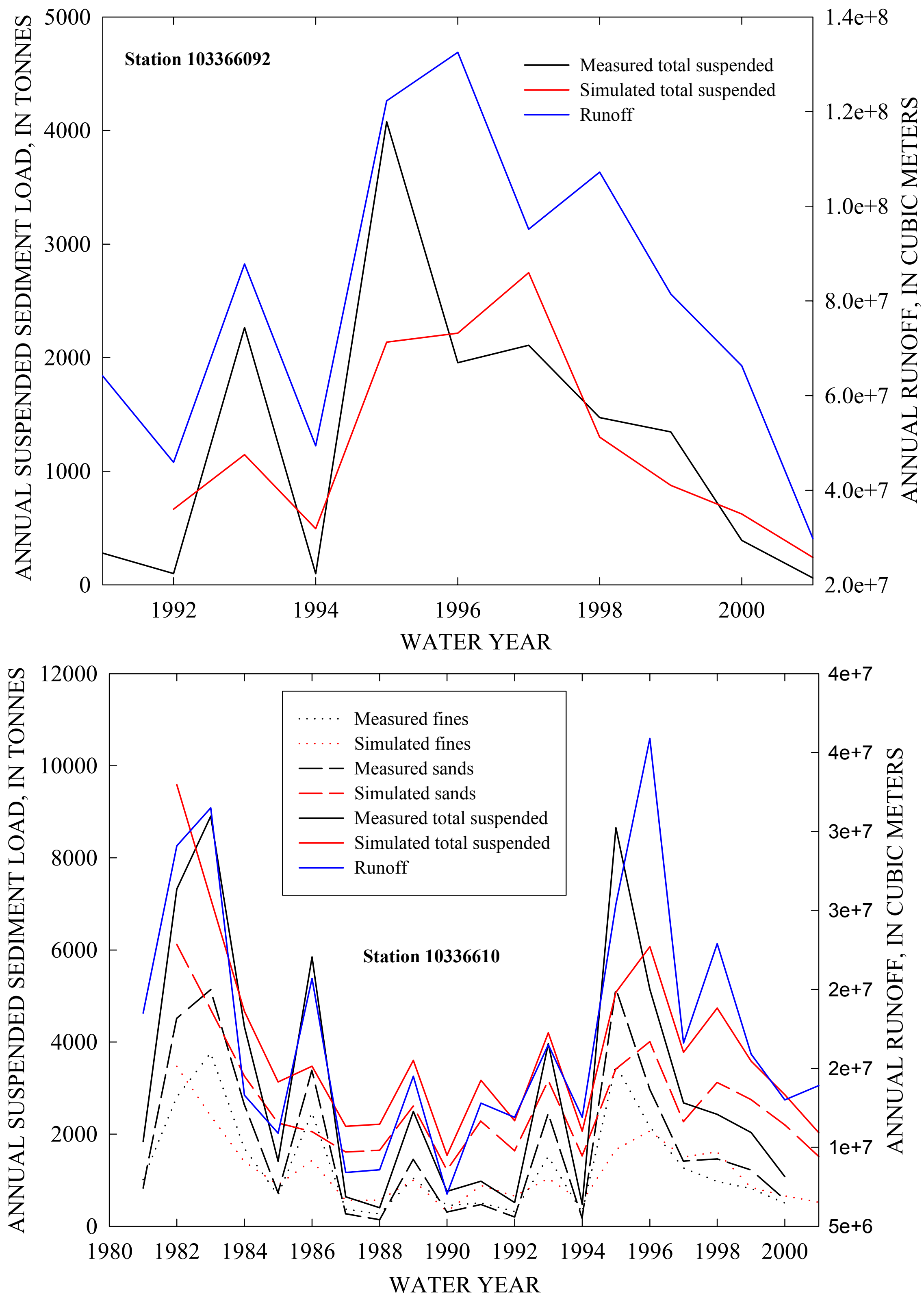

Figure 5-63. Comparison of measured and simulated annual loads at mid-reach gage 103366092 (A) and downstream gage 10336610 (B) for the period of 1991-2001 and 1981-2001, respectively.

Table 5-11. Relative contributions of uplands and streambanks to suspended sediment load during validation period, Upper Truckee River.

Sediment size	Uplands (%)	Streambanks (%)	Total (T/y)
Fines	49	51	782
Sands	10	90	2110
Total suspended	21	79	2892

Annually-averaged monthly sediment load of fines, sands, and total suspended sediment are shown in Figure 5-64. It shows that runoff in the fall and winter is relatively large, and that during spring it is relatively low. Consequently, the sediment loads in fall and winter are also high, whereas it is too small in spring. This may partly explain the considerable scatter in Figure 5-62. It appears that simulated snowfall in the fall and winter periods melts too early due to overly warm temperatures at high elevations.

Of the total amount of fines delivered to the channel 49% is eroded from the uplands and 51% from the streambanks (Table 5-11). Streambanks are the principal source of sediments contributing 90% of the sands and 79% of the total suspended sediment over the validation period. About half of the fines emanating from the Upper Truckee River come from streambanks, the rest from uplands. Median, annual loadings of fines at the downstream, index station (10336610; 1010 T/y) compare well simulated values of 782 T/y (Table 5-11).

CONCEPTS 50-Year Simulation

A simulation with a 50-year flow record was performed to determine temporal trends in sediment loads. The channel geometry is the same as in the validation simulation, except the geometry of cross sections 19 through 26 is replaced by that surveyed in 2002. All physical properties are those determined from the validation. The records of tributary and lateral inflow of water and sediments were constructed in the same way as for the validation case. The runoff in years 22 through 42 is the same as in years 1 through 21 of the 50-year flow record, except the large storm event on January 2 of year 17 is not repeated in year 38. The runoff in years 43 through 50 is the same as in years 1 through 8.

Changes in channel top width and bed elevation over the 50-year simulation period are shown in Figure 5-65. Channel top-width changes significantly at cross sections 24 (34 m), 22 (12 m), and 19 (8 m) and represent the principle form of channel change over the next 50 years. The average change in top width is 2.7 m for the 23.4 km reach. Changes in thalweg elevation range from 0.2 m of erosion at cross section 20 to 1.1 m of deposition at cross section 24, thus channel depths will generally decrease over the 50-year simulation period.

Although runoff volumes are repeated for years 1-21 and 22-42, and 43-50, suspended-sediment loads decrease over the period, not withstanding another simulated January 1997 runoff event. Figure 5-66 shows the simulated annual runoff, and annual loads of fines, sands, and total suspended sediments at the outlet of the Upper Truckee River. Channel adjustments in the first 23 years comprise 58 percent of the total change in the 50-year simulation.

Streambanks are the principal source of sediments, contributing 80% of the sands and 66% of the total suspended sediment. Table 5-12 lists the sources of fines and sands delivered to the channel outlet and their relative contributions. Of the total amount of fines delivered to the channel over the 50-year simulation period, 63% is eroded from the uplands and 37% from the streambanks.

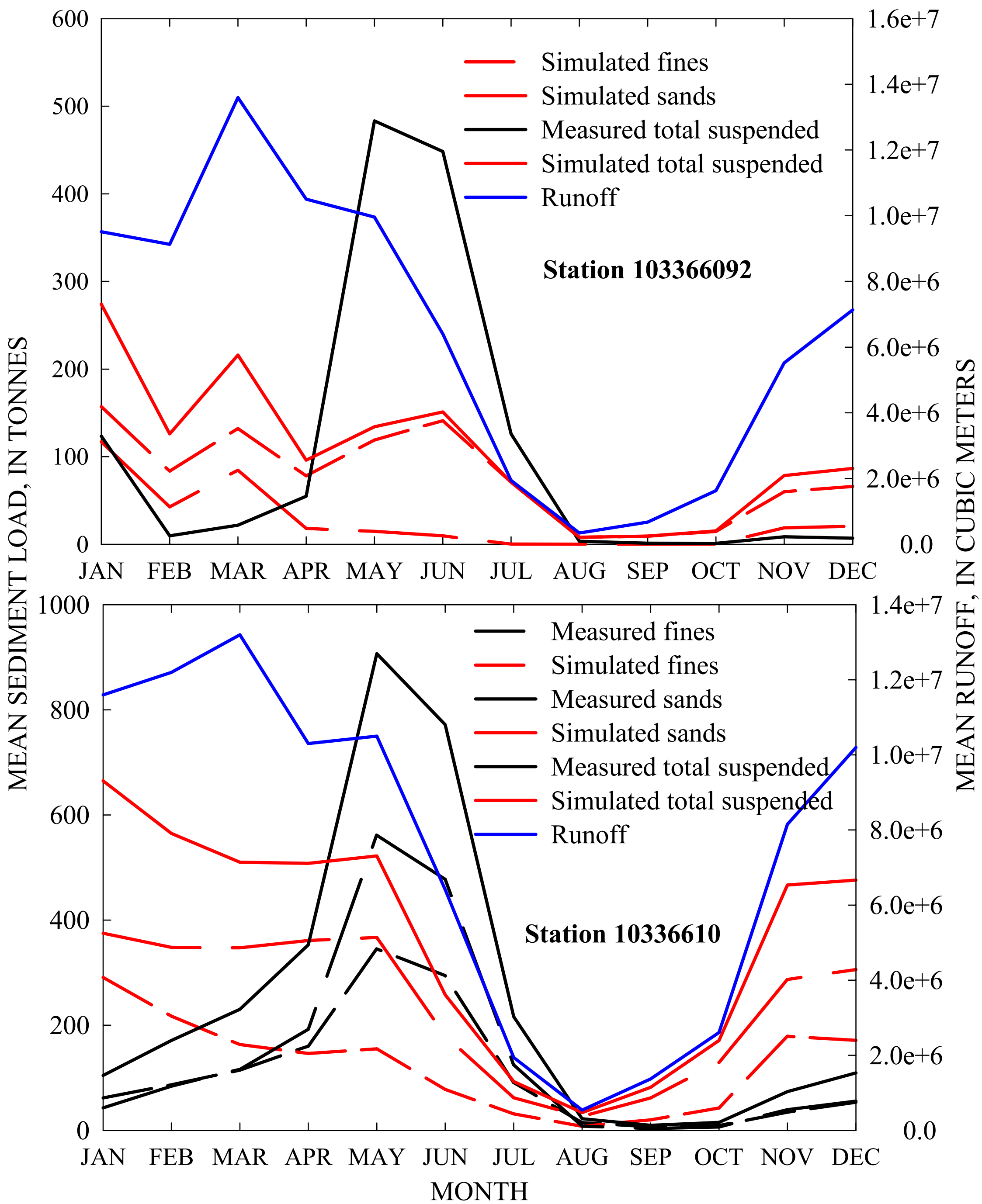

Figure 5-64. Comparison of measured and simulated annually-averaged monthly sediment loads and runoff for stations 103366092 (A) and 10336610 (B).

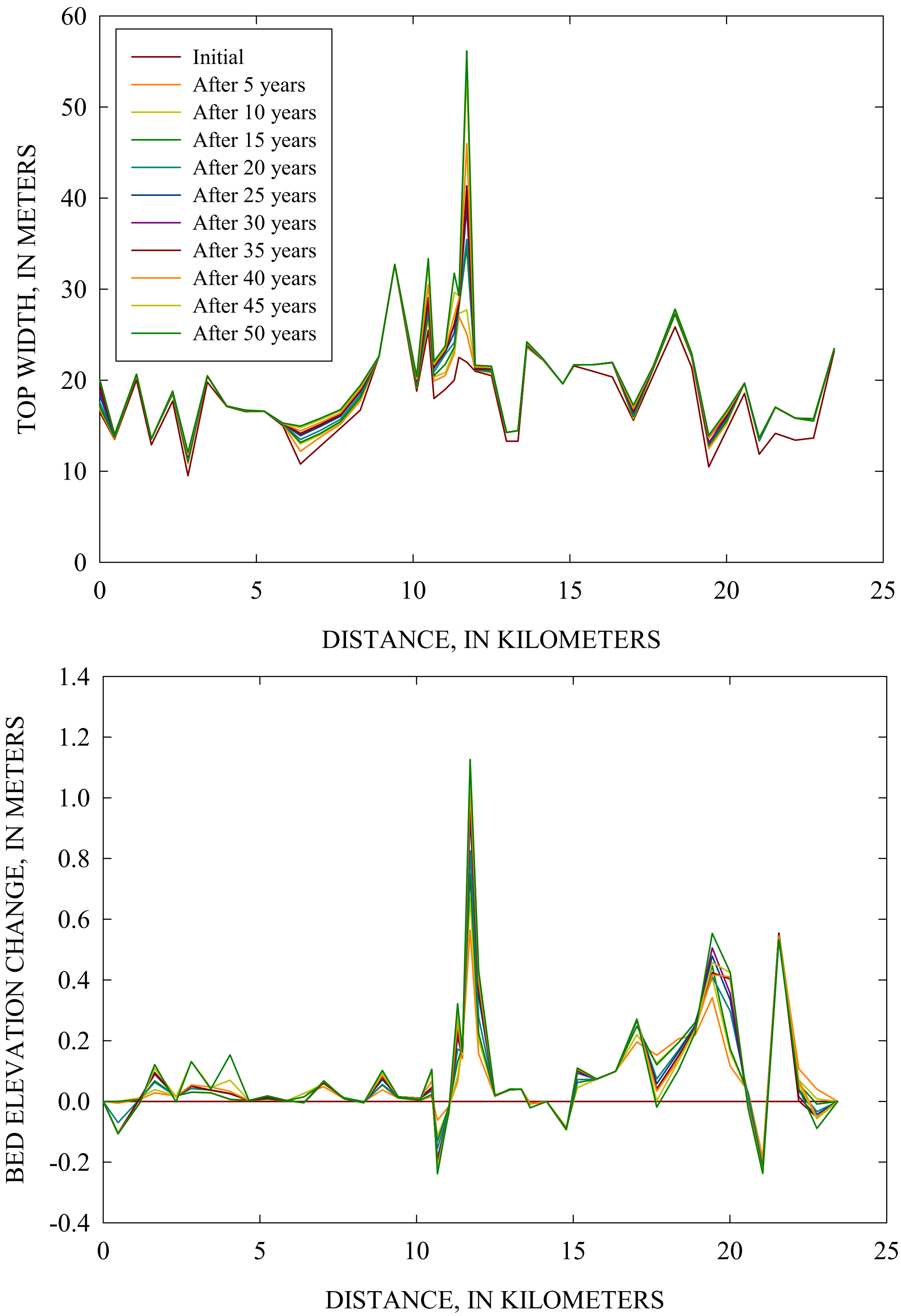

Figure 5-65. Simulated changes in bank top-width and bed elevation of the Upper Truckee River over a 50-year period.

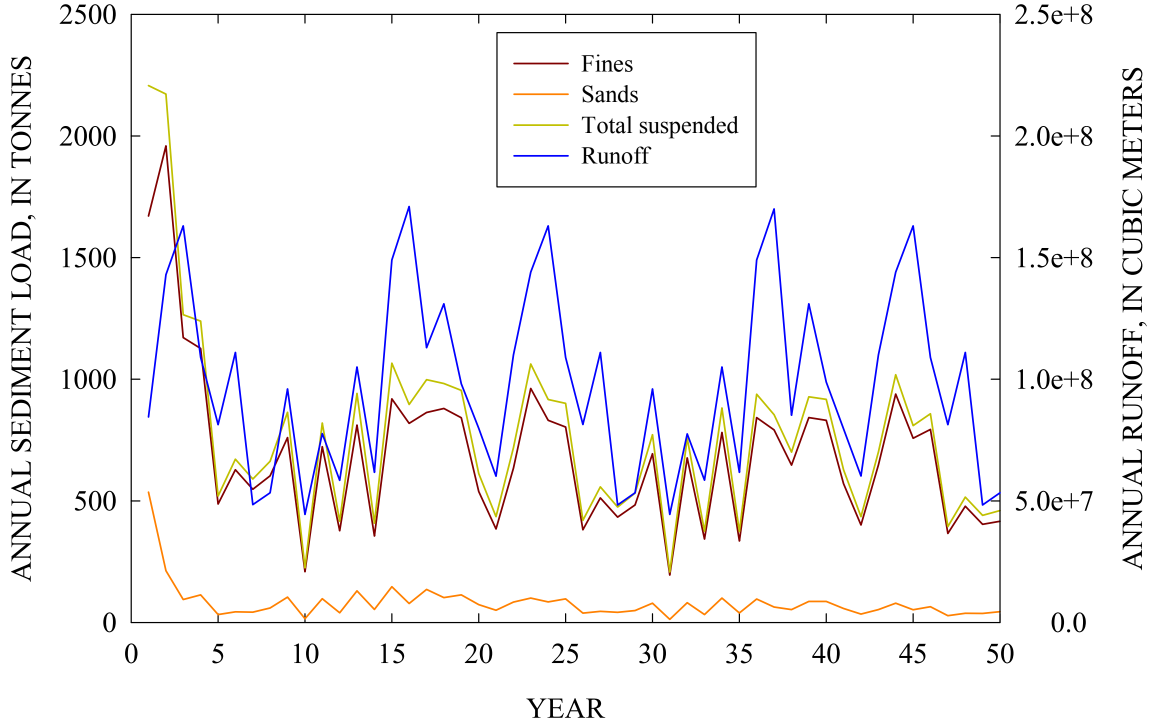

Figure 5-66. Simulated annual runoff and loads of fines, sands, and total suspended sediments delivered to the lake for the 50-year period.

Table 5-12. Relative contributions of uplands and streambanks to suspended sediment load over the 50-year simulation period.

Sediment size	Uplands (%)	Streambanks (%)	Total (T/y)
Fines	63	37	803
Sands	20	80	1714
Total suspended	34	66	2517

5.4.3 Ward Creek

AnnAGNPS

Three gaging stations (10336676 at the lower end, 10336675 in the middle and 10336674 at the upper end) are used to validate simulations of AnnAGNPS within the Ward Creek watershed. There were several techniques used to evaluate the performance of AnnAGNPS in the Ward Creek watershed by comparing annual and monthly runoff and sediment, as well as an evaluation of the sources of the runoff and sediment within the watershed.

Annual Runoff. Simulated annual runoff was determined from 1980 to 2001 at stations 10336674 10336675, while measured runoff was available from 1992 to 2000 (Figures 5-67 and

5-68). Simulated annual runoff was determined from 1980 to 2001 at the downstream, index station 10336676, while measured runoff was available from 1980 to 2000 (Figure 5-69). As with the Upper Truckee River watershed simulations, simulated annual runoff compares well with measured values.

Monthly Runoff. The simulated monthly runoff was compared with the measured for all months from 1992-2000 at the USGS gaging station #10336674 (Figure 5-70) and at USGS gaging station #10336675 (Figure 5-71). The simulated monthly runoff was compared with the measured for all months from 1980-2000 at the USGS gaging station #10336676 (Figure 5-72). Although the graphs show reasonable agreement between absolute values, monthly values are still somewhat overestimated during the winter months probably due to problems with temperature gradients.

Annual Fine-Sediment Loads. Simulated annual fine-sediment loads were compared to calculated annual fine-sediment transport at the three stations in the watershed (Figures 5-73 to 5-75). Results show that at the upstream-most station (10336674) fine-sediment contributions from upland sources was higher than the lower gages. This is in general agreement with observations of Stubblefield (2002) and the load calculations for these gages in section 3.4. As with the simulations of the other watersheds, the proportion of sediment from upland areas making up the total suspended-sediment load passing downstream stations decreases with increasing distance from the headwaters as a probable result of more channel erosion occurring downstream.

Sources. TA significant amount of runoff occurs in the upper end of the watershed where the land cover is rock outcrop (Figure 5-76). Total erosion and fine-sediment yield that reaches the edge of each AnnAGNPS cell shows considerable variability throughout the watershed, but is generally higher in the upper end of the watershed owing to steeper slopes and unconsolidated geologic formations (Figure 5-78). These have been noted by Stubblefield (2002) and others, and are documented in this report with the short period of loadings data from station 10336670.

Recurrence Interval for the Annual Maximum Instantaneous Peak Discharge. Tables 5-13 through 5-15 list the observed annual peak discharges at stations 10336674, 10336675, and 10336676, respectively, with the simulated, annual peak discharges computed by AnnAGNPS routed downstream by CONCEPTS. Simulated annual peak discharges are about 50 percent larger than those observed. The 2-year, 5-year, 10-year, and 20-year peak discharges calculated from the observed annual peaks are 6.6, 13.7, 20.1, and 27.6 m^3/s, respectively.

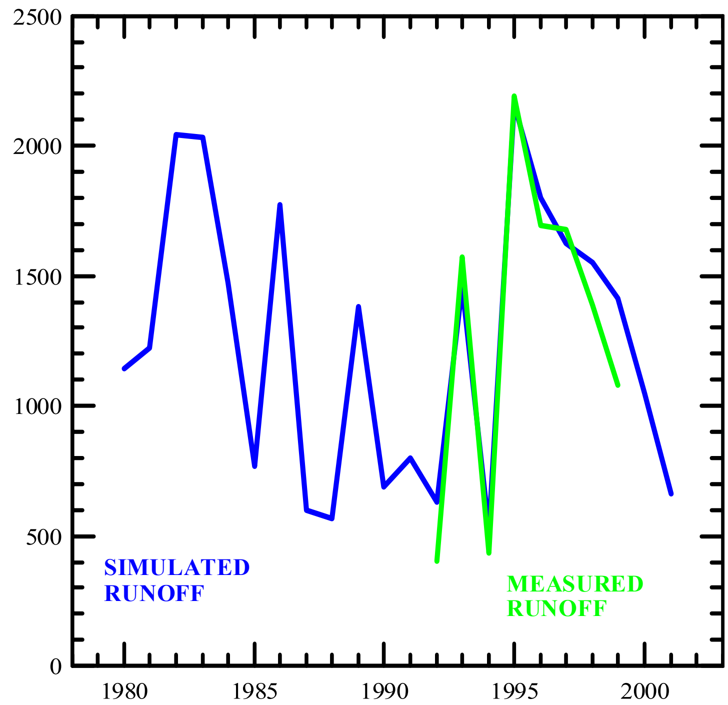

Figure 5-67. AnnAGNPS simulated and measured annual runoff at station 10336674, Ward Creek watershed.

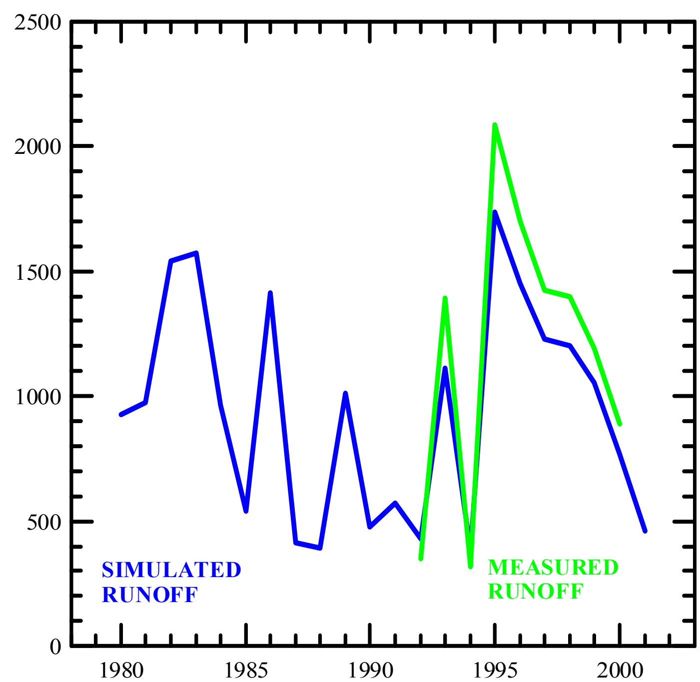

Figure 5-68. AnnAGNPS simulated and measured annual runoff at station 10336675, Ward Creek watershed.

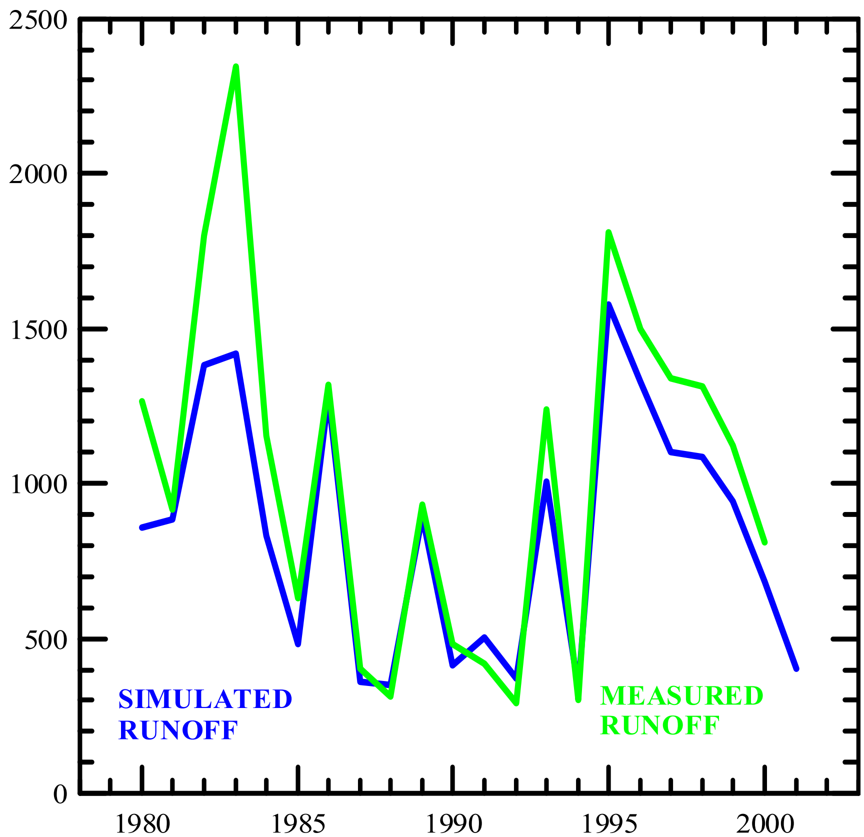

Figure 5-69. AnnAGNPS simulated and measured annual runoff at station 10336676, Ward Creek watershed.

At USGS gaging station 10336675 the simulated annual peak discharges agree better for the less frequent large runoff events, but are still much too big for the more frequent moderate runoff events. The simulated peak discharge (66.4 m^3/s) for the January 1-2, 1997 runoff event agrees very well with that observed (67.1 m^3/s). The 2-year, 5-year, 10-year, and 20-year peak discharges calculated from the observed annual peaks are 9.3, 21.9, 35.8, and 55.1 m^3/s, respectively. The corresponding simulated peak discharges are: 10.5, 23.6, 38.7, and 60.9 m^3/s, respectively.

At USGS gaging station 10336676 the agreement between observed and simulated annual peak discharges worsens for annual peak discharges falling within the 1- to 2-year recurrence interval. The observed peak discharges reduce between stations 10336675 and 10336676, whereas the simulated peak discharges increase very slightly. The 2-year, 5-year, 10-year, and 20-year peak discharges calculated from the observed annual peaks are 7.9, 19.7, 33.1, and 51.8 m^3/s, respectively. The corresponding simulated peak discharges are: 11.9, 25.1, 39.2, and 58.6 m^3/s, respectively.

Table 5-13. Comparison of measured and simulated annual peak discharge at USGS gaging station 10336674. Values are in cubic meters per second.

Water year	Observed	Water year	Observed
1992	1.44	1997	34.6
1993	8.95	1998	6.29
1994	2.27	1999	7.48
1995	6.65	2000	7.42
1996	12.29	2001	5.66

Table 5-14. Comparison of measured and simulated annual peak discharge at USGS gaging station 10336675. Values are in cubic meters per second.

Water year	Observed	CONCEPTS	Water year	Observed	CONCEPTS
1992	2.86	4.00	1997	67.1	66.4
1993	11.8	8.06	1998	9.54	22.2
1994	2.46	4.84	1999	11.0	8.93
1995	10.5	18.4	2000	12.4	7.61
1996	24.5	29.0	2001	4.96	5.08

Table 5-15. Comparison of measured and simulated annual peak discharge at USGS gaging station 10336676. Values are in cubic meters per second.

Water year	Observed	CONCEPTS	Water year	Observed	CONCEPTS
1981	4.19	9.44	1992	3.11	4.08
1982	51.0	44.3	1993	13.1	8.81
1983	18.0	15.91	1994	2.58	5.69
1984	9.94	29.2	1995	14.5	20.9
1985	4.64	9.40	1996	28.9	31.1
1986	24.4	50.1	1997	71.6	72.6
1987	3.20	6.87	1998	10.5	26.3
1988	1.36	5.70	1999	11.2	9.44
1989	6.03	13.3	2000	12.2	7.59
1990	2.46	5.75	2001	5.72	5.39
1991	3.37	8.70			

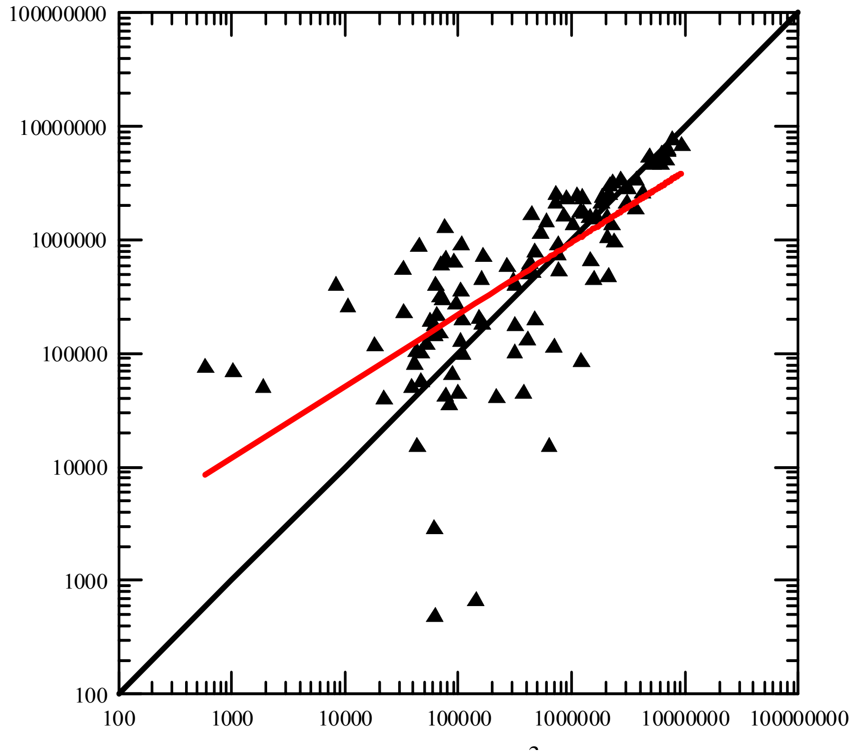

Figure 5-70. AnnAGNPS simulated versus measured monthly runoff during 1991-2000 at the upstream station 10336674, Ward Creek watershed.

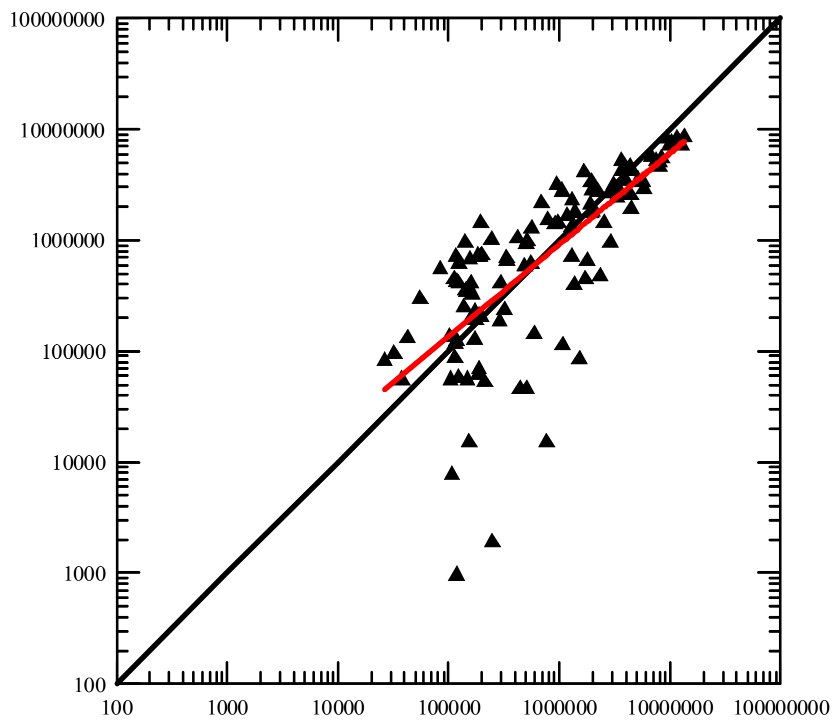

Figure 5-71. AnnAGNPS simulated versus measured monthly runoff during 1991-2000 at the middle station 10336675, Ward Creek watershed.

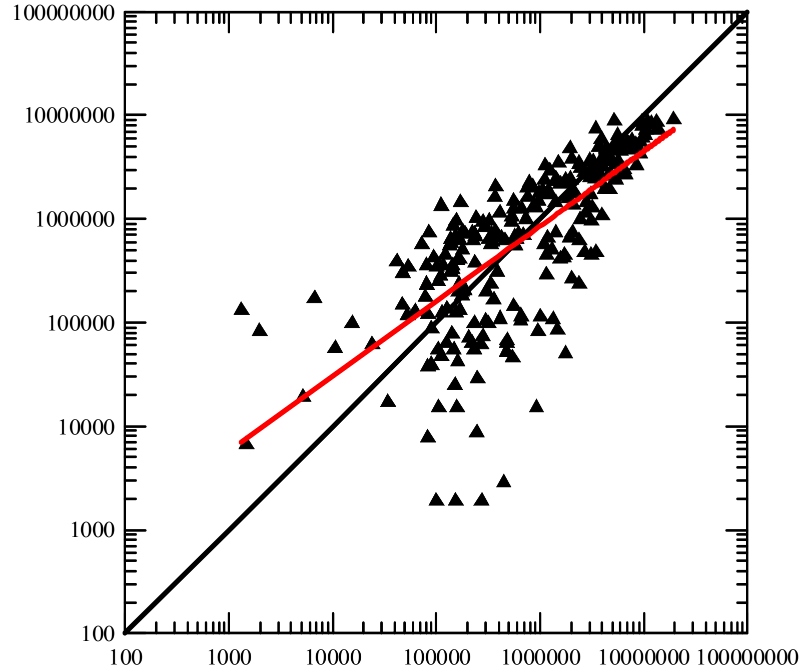

Figure 5-72. AnnAGNPS simulated versus measured monthly runoff during 1981-2000 at the downstream station 10336676, Ward Creek watershed.

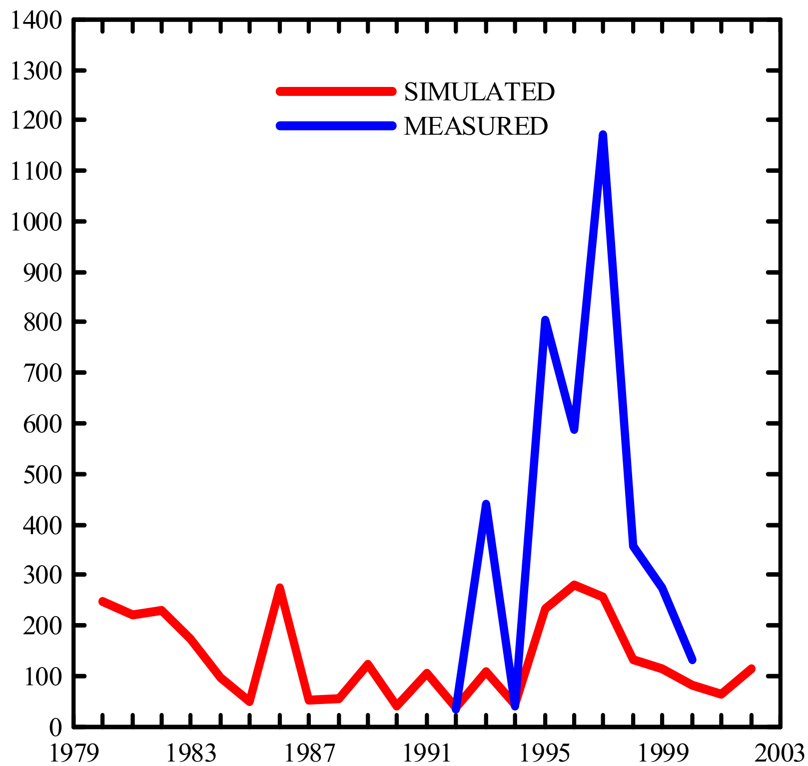

Figure 5-73. AnnAGNPS simulated and measured yearly sediment at the upstream station 10336674, Ward Creek watershed.